

# Practical Applications of ADS-B and FDM in General Aviation

An Embry-Riddle Aeronautical University Perspective  
Professor Kenneth Byrnes

# Agenda

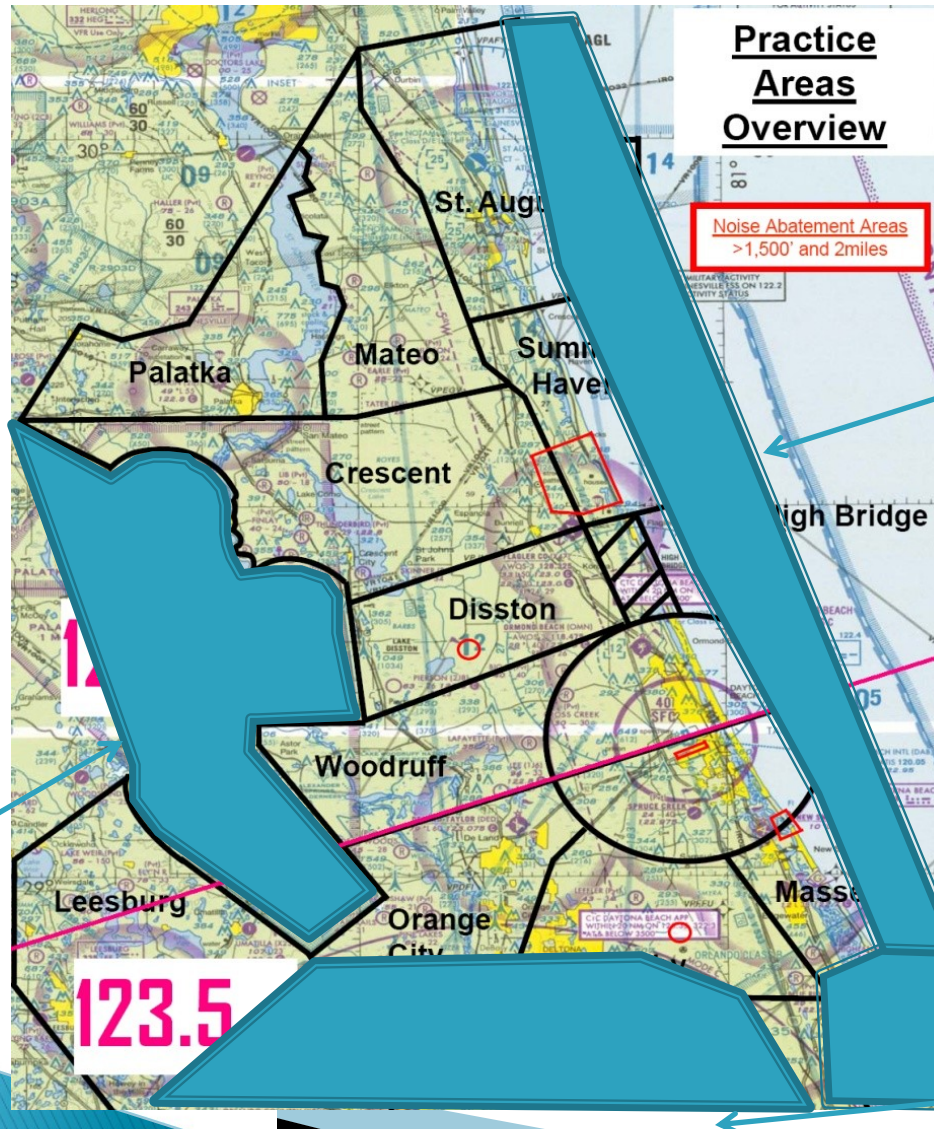
- ▶ Why ADS-B?
- ▶ Example of Practical Application
- ▶ Future of ADS-B
- ▶ Flight Data Monitoring
- ▶ FDM Capabilities
- ▶ Conclusion



# Why ADS-B?

## Airspace Limitations

- 20% of U.S. training occurs in our district
- DAB 800 ops/day
  - 27<sup>th</sup> busiest
- 3 Airports within top 10 busiest (pvt ATC)
- ERAU schedules 300 flight activities daily
  - 70,000 hours/yr
  - 130,000 ops/yr
- Highest threat to our safety in a mid air collision
- 2 fatal mid-airs
  - '95 and '99



No off shore operations

NASA

MCO Class B



# ADS-B at ERAU



## ▶ Competitive fly off (2002 - 2003)

- ADS-B
- Traffic Information System (TIS)

## ▶ ADS-B selected

- Non –Radar environment at the Prescott campus
- Real time position updates (no sweep delay)
- Maturity of the technology (Capstone)
- Availability of desktop management system
  - Comprehensive Real Time Analysis of Broadcast Systems (CRABS)
- Improved low altitude capability
  - Below 1,000 feet in the practice area in the pattern at remote airfields.
  - FIS-B (Weather)

## ▶ 2003, ERAU Equipped 100 aircraft

- Significant investment in safety
- Changed the nature of the pilots situational awareness





# Installation





# ERAU Piper Arrow-Seminole Panel



# ERAU Diamond DA-42L360





# ERAU Cessna Panel





NAV1 109.75 ↔ 112.60 OMN  
NAV2 112.20 112.60 OMN

GS 0KT

DTK 219°

TRK 335°

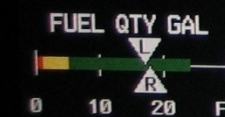
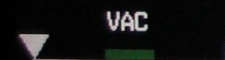
ETE \_:\_

122.825 ↔ 123.300  
123.300

COM1  
122.825 COM2

MAP - NAVIGATION MAP

TRACK UP



ENG 1995.3 HRS

—ELECTICAL—

M BUS E

24.5 VOLTS 24.5

M BATT S

-9.5 AMPS 0.0

ENGINE

MAP

MAP WPT AUX NRST

DCLTR

SHW CHRT

CHKLST



GARMAN

NAV1 109.75 ↔ 112.60  
 NAV2 112.20 112.60

GS 0KT

DTK 219°

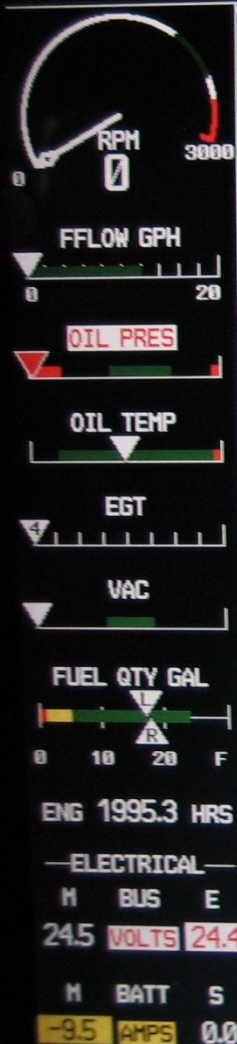
TRK 335°

ETE —:—

122.825 ↔ 123.300 COM1  
 123.300 122.825 COM2

MAP - NAVIGATION MAP

TRACK UP



MAP WPT AUX NRST

ENGINE

MAP

DCLTR

SW CHRT

CHKLIST

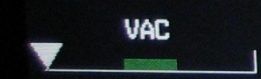


NAV1 109.75 ↔ 112.60 OMN  
NAV2 112.20 112.60

→ KDAB

DIS 0.5NM BRG 227°

122.825 ↔ 123.300 COM1  
123.300 122.825 COM2



ENG 1995.3 HRS

ELECTRICAL  
M BUS E  
24.6 VOLTS 24.5

M BATT S  
-9.5 AMPS 0.0



74  
68  
62  
55

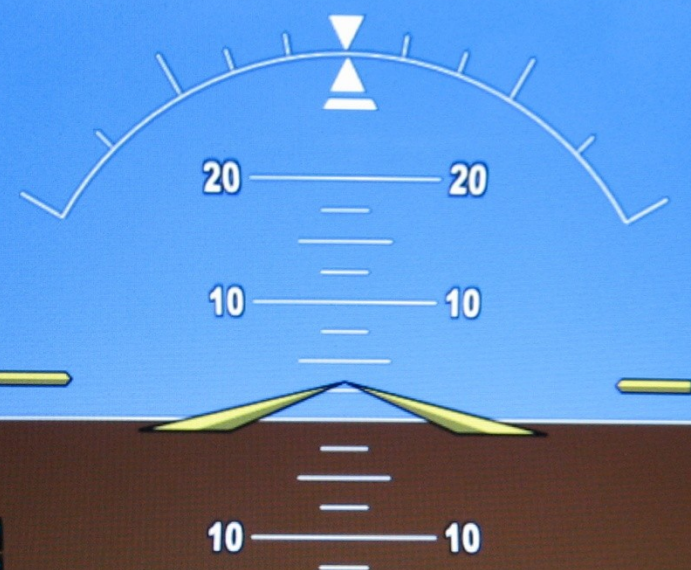
TAS 0KT

OAT 19°C

Y  
G  
X  
R

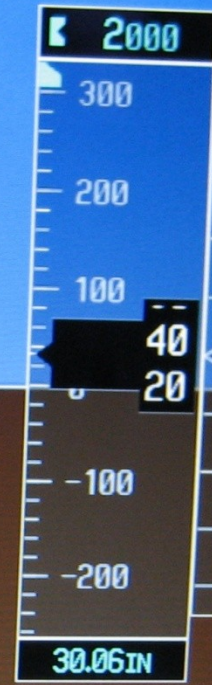
NO WIND DATA

HDG 242°



252°

CRS 219°



2  
1  
1  
2

OIL PRESSURE  
LOW VACUUM



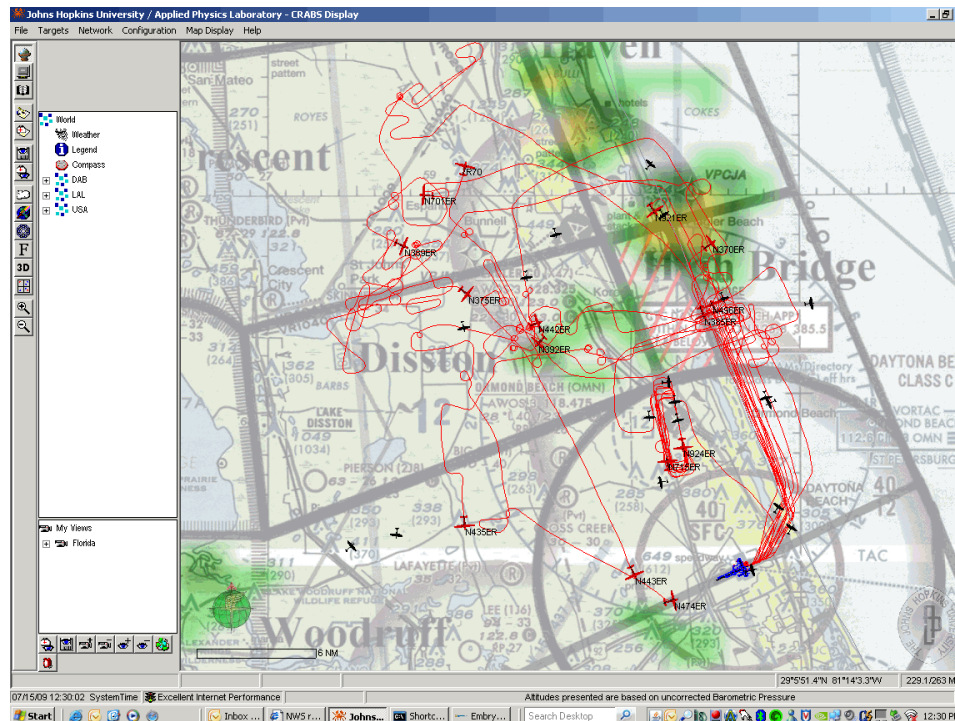
XPDR 0157 GND R LCL 7:49:38AM

ENGINE INSET PFD OBS CDI XPDR IDENT TMR/REF NRST ADVISORY



# Management System

- ▶ On the ground, operators can display traffic and weather information on computer screens



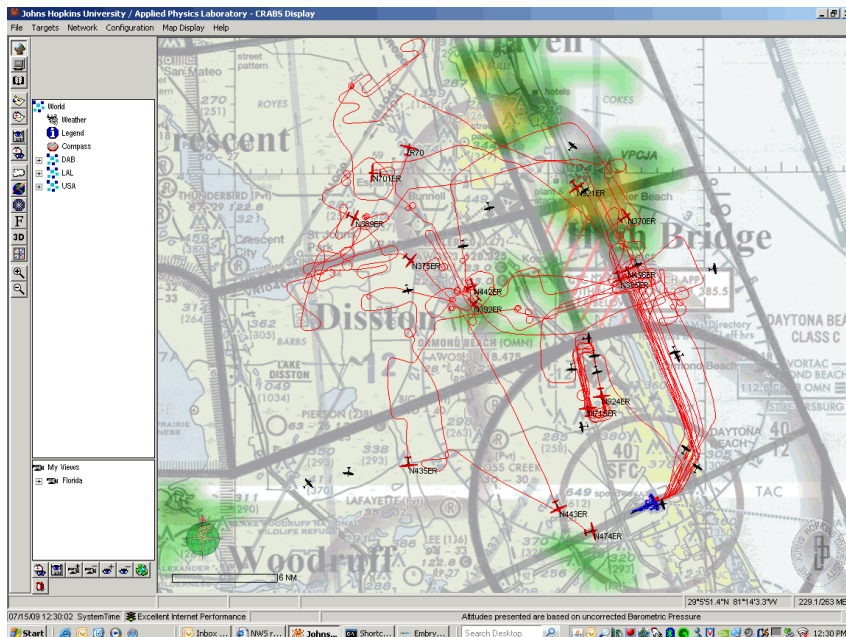
# Practical ADS-B Uses

# Airborne planning tool

# Limited FOQA

# Investigation

# Research



# Strategic

# Collision Avoidance

# Situational awareness

## Below radar/On the ground

## Controller to pilot

# Pilot to pilot



# Tactical



# NMAC

- ▶ August 2008
- ▶ VFR traffic pattern
- ▶ High wing vs. Low wing



Photo Copyright © Adam Wright

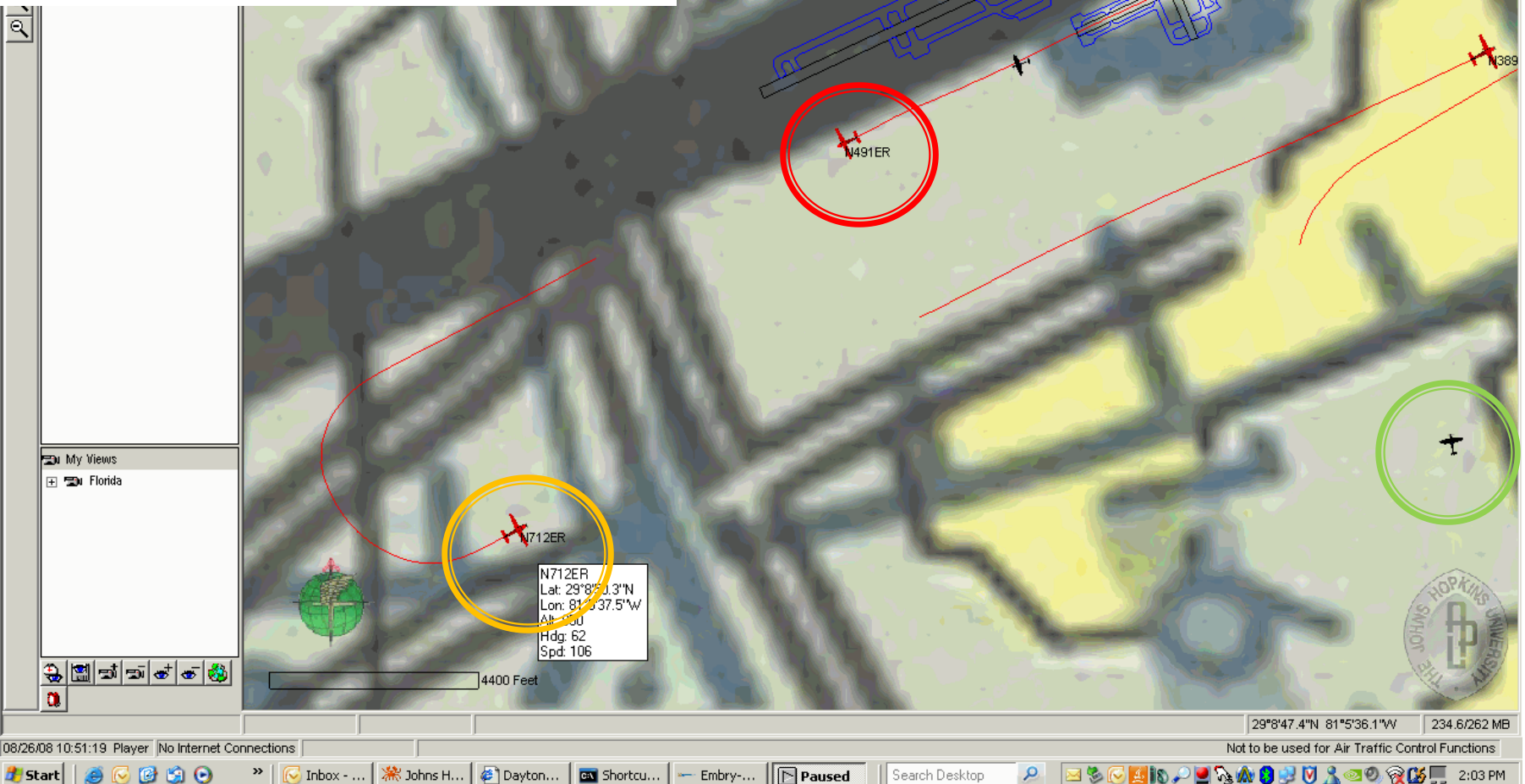
AIRLINERS.NET



Photo Copyright © Adam Wright

AIRLINERS.NET

- ▶ 8 aircraft in traffic pattern
- ▶ Controller in-training asked Piper to extend upwind
- ▶ Traffic entering from the south missed radio calls
- ▶ Controller forgot about Piper and sequenced Cessna behind entering traffic





**Paused**

Open Multi Play Pause Stop Options Files

Playback Options

Start Time 08/26/08 10:50:00 AM  
 Stop Time 08/26/08 11:00:00 AM ☐ Repeat

Playback Speed: ☒ Real-Time ☐ Non Real-Time  
 Scale Factor: 1

Play Status

Last Msg 10:51:33 Last Local 14:04:11  
 Next Msg 10:51:33 Act. Speed Ratio 0.0

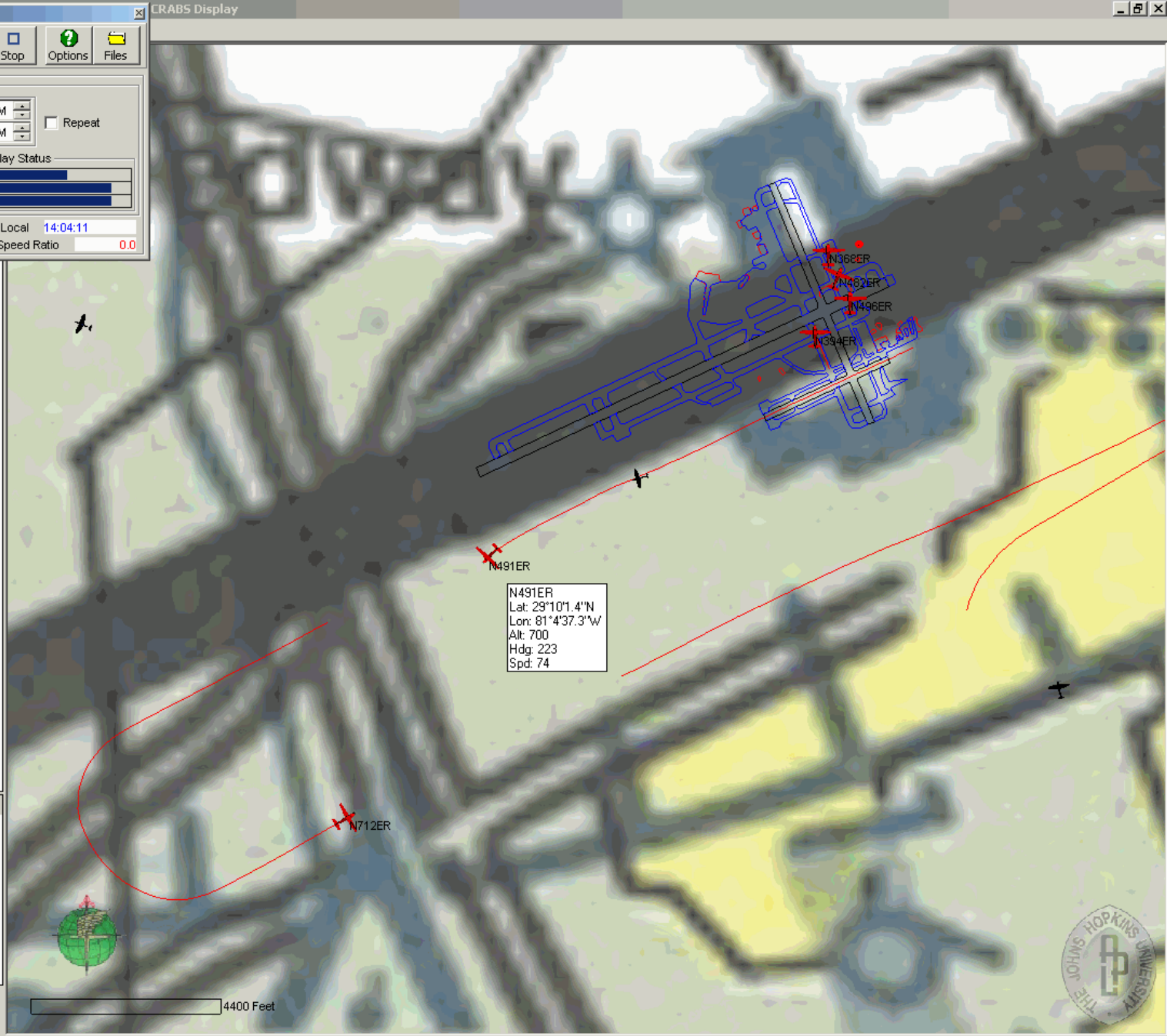
USA

F 3D

My Views

Florida

4400 Feet







Playback Options

Start Time 08/26/08 10:30:00 AM

Stop Time 08/26/08 11:00:00 AM

☐ Repeat

Playback Speed

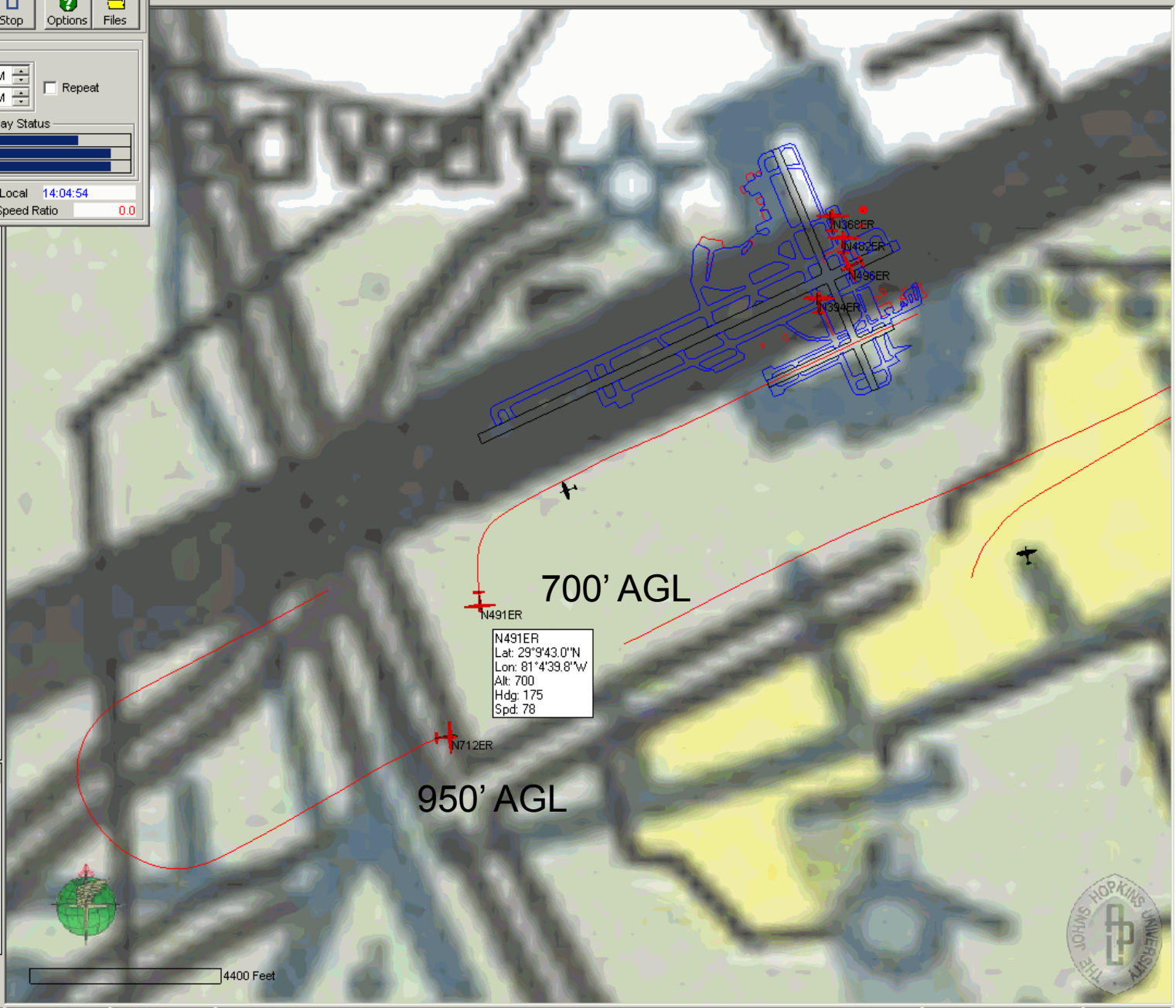
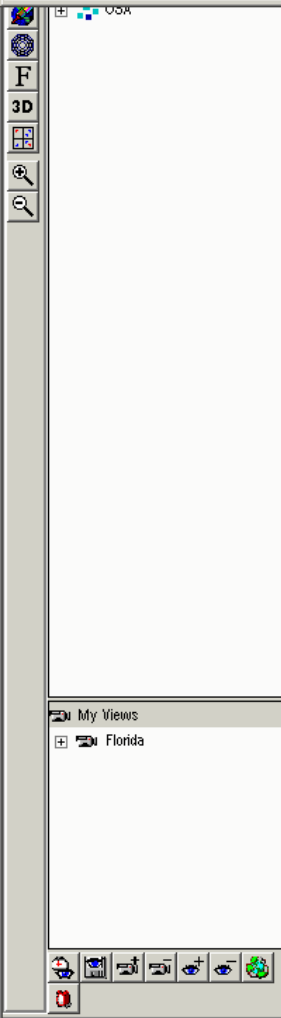
☒ Real-Time Scale Factor 1

☐ Non Real-Time

Play Status

Last Msg 10:51:48 Last Local 14:04:54

Next Msg 10:51:48 Act.Speed Ratio 0.0



Paused

Open Multi Play Pause Stop Options Files

Playback Options

Start Time 08/26/08 10:50:00 AM  
Stop Time 08/26/08 11:00:00 AM ☐ Repeat

Playback Speed: ☒ Real-Time ☐ Non Real-Time  
Scale Factor: 1

Play Status

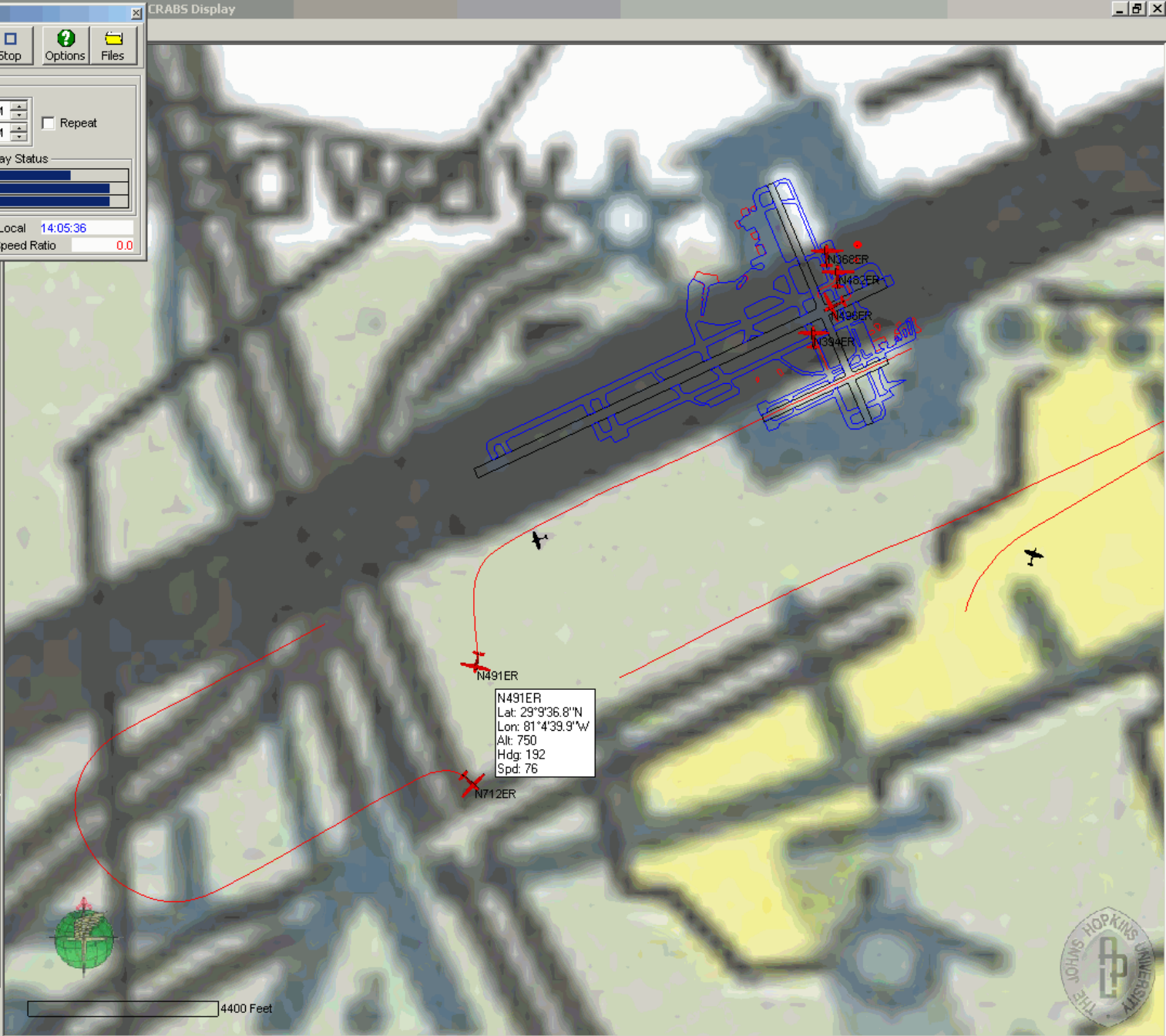
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Next Msg 10:51:53 Act.Speed Ratio 0.0

3D

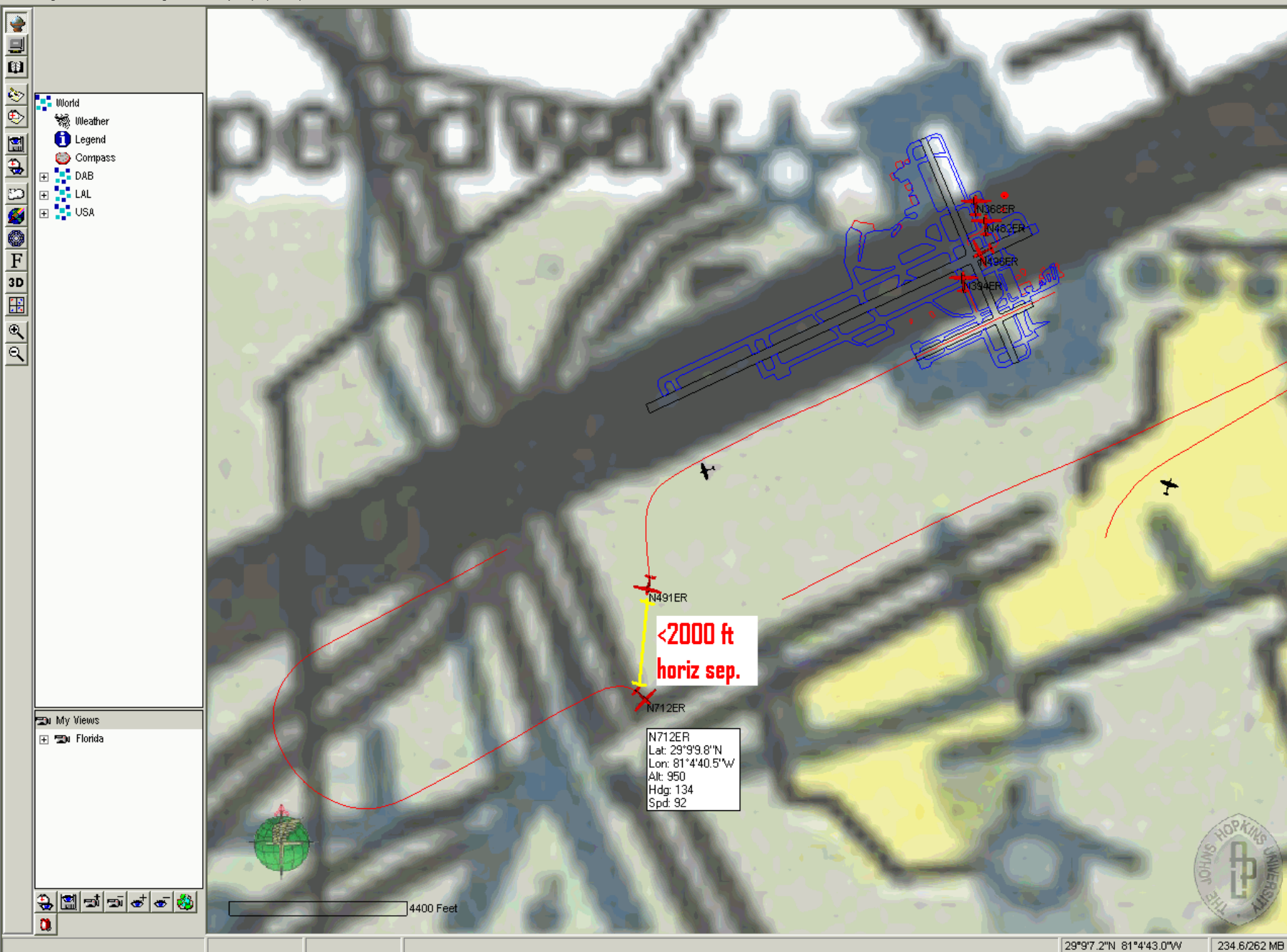
My Views

Florida

4400 Feet







29°9'7.2\"N 81°4'43.0\"W

234.6/262 MB



# Future of ADS-B

- ▶ Will provided an unprecedented level of situational awareness for ATC, GA, and Air Carriers
- ▶ Great tool for management and investigators
- ▶ **Overall: immeasurable increase in SAFETY**



# Best investment for lives saved

- ▶ C-172 round-dial: \$20,000 (est. 2003)
  - Includes MX-20 MFD
- ▶ C-172 G1000: \$7,000 (est. 2007)
  - Not pre-wired
- ▶ DA-42 G1000: \$6,000 (January 2009)
  - 32 hr. labor: \$1,450
  - GDL-90: \$4,590
  - Aircraft already pre-wired by factory

# Flight Data Monitoring

G1000



# Flight Data Monitoring Basics

- ▶ Data recorded to SD card in top card slot on MFD
- ▶ Recording rate is once per second
- ▶ Data is readable in Microsoft Excel and can be converted for 3-D viewing in Google Earth



# Flight Data Logging

## 51 Parameters



- Date
- Time
- GPS altitude (MSL)
- GPS altitude (WGS84 datum)
- Baro-Corrected altitude (feet)
- Baro Correction (in/Hg)
- Indicated airspeed (kts)
- Vertical speed (fpm)
- GPS vertical speed (fpm)
- OAT (degrees C)
- True airspeed (knots)
- Pitch Attitude Angle (degrees)
- Roll Attitude Angle (degrees)
- Lateral and Vertical G Force (g)
- Ground Speed (kts)
- Ground Track (degrees magnetic)
- Latitude (degrees; geodetic; +North)
- Longitude (degrees; geodetic; +East)
- Magnetic Heading (degrees)
- HSI source
- Selected course
- Com1 /Com2 frequency
- Nav1 /Nav2 frequency
- CDI deflection
- VDI/GP/GS deflection
- Wind Direction (degrees)
- Wind Speed (knots)
- Active Waypoint Identifier
- Distance to next waypoint (nm)
- Bearing to next waypoint (degrees)
- Magnetic variation (degrees)
- Autopilot On/Off
- AFCS roll/pitch modes
- AFCS roll/pitch commands
- GPS fix
- GPS horizontal alert limit
- GPS vertical alert limit
- WAAS GPS horizontal protection level
- WAAS GPS vertical protection level
- Fuel Qty (right & left)(gals)
- Fuel Flow (gph)
- Fuel Pressure (psi)
- Voltage 1 and/or 2
- Amps 1 and/or 2
- Engine RPM
- Oil Pressure (psi)
- Oil Temperature (deg. F)
- TIT (deg. F)
- Manifold Pressure (in. Hg)
- CHT
- EGT



Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., 37°25'19.1"N, 122°05'06"W

Places

- My Places
- Sightseeing Tour
  - Make sure 3D Buildings layer is checked
- Temporary Places
- Garmin Flight Data log\_110408\_1407
  - Flight Log

Layers

Earth Gallery >>

- Primary Database
- Borders and Labels
- Places
- Photos
- Roads
- 3D Buildings
- Ocean
- Weather
- Gallery
- Global Awareness
- More

Imagery Date: 12/8/2010

Image © 2011 TerraMetrics  
© 2011 Google  
© 2011 Europa Technologies

29°11'47.26" N 81°04'39.15" W elev. 25 ft

15:03:37 15:03:07 15:02:36 15:16:59 15:17:29 15:18:34 15:19:05 15:19:35 15:20:10 15:20:40 15:21:13 15:21:44 15:22:14 15:22:46 14:28:54 14:28:22 14:27:52

15:17:29

lcl date=2011-04-08  
lcl time=15:17:29  
utcofst=-04:00  
abwpt=RW16  
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longitude=-81.0710526  
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baroa=30.10  
altmsl=958.3  
oat=25.5  
ias=97.08  
gndspd=89.94  
vspd=153.94  
pitch=-1.94  
roll=-0.79  
latac=0.02  
normacc=0.10  
hdg=160.3  
trk=162.9  
volt1=28.2  
volt2=28.2  
amp1=0.8  
amp2=0.1  
fdtyl=18.86  
fdtyr=19.41  
e1 flow=7.60  
e1 oilt=180.84  
e1 oilp=70.99  
e1 rpm=2003.4  
e1 cht1=295.65  
e1 cht2=291.95  
e1 cht3=291.11  
e1 cht4=302.21  
e1 egt1=1235.84  
e1 egt2=1239.40  
e1 egt3=1255.34  
e1 egt4=1221.93  
altgps=880.7  
tas=100  
hsis=NAV1  
ois=156.2  
nav1=112.60  
nav2=112.60  
com1=120.700  
com2=121.900  
hcdi=0.176  
wndspd=9.28  
wnddir=127.4  
wptdst=1.9  
wptbrg=162.5  
magvar=0.0  
vspdg=-303.1  
gpstix=3DDiff  
hal=556  
hplwas=10  
hpltd=14.5  
vplwas=16

Directions: [To here](#) - [From here](#)

Daytona Beach

South Daytona

Google

©2010

Eye alt: 10.48 mi



File Tools Help

Data Viewing Data Analysis Event Database

## Analysis Events

- ☐ Exceedence Events
  - ☒ Engine Events
    - ☒ Max Oil Temp
    - ☒ Max Oil Pressure
    - ☒ Min Oil Pressure After Engine Start
    - ☒ Max RPM
    - ☒ Min Total Fuel Qty
    - ☒ Max CHT
    - ☒ In-Flight Engine Shutdown
    - ☒ Excessive Starter Engage
    - ☒ Excessive Runup RPM Drop
  - ☐ Ground Events
  - ☐ Takeoff Events
  - ☐ Climb Events
  - ☒ Flight Events
    - ☒ VNE
    - ☒ Max Normal Acceleration
    - ☒ Min Normal Acceleration
    - ☒ Max Bank
    - ☒ Max Bank at Low Altitude
    - ☒ Max Pitch
    - ☒ Min Pitch
    - ☒ Max Altitude
  - ☐ Approach Events
  - ☐ Landing Events
  - ☐ GPS Integrity Events
  - ☐ Flight Phases (Informational Only)

## Run Analysis

Start Analysis

Abort Analysis

- ☒ Archive Files After Analysis
- ☒ Use Google Earth
- ☒ Save Events in Database

ERAU

Aviation Safety Department

Done.

June 22, 2012

26

...\\Pending\_Data\\N368ER\\log\_110729\_123310\_K5GJ.csv



File Tools Help

Data Viewing Data Analysis Event Database

## Analysis Events

- ☒ Engine Events
- ☒ Ground Events
  - ☐ Excessive Taxi Speed
  - ☐ Excessive Ramp Speed
  - ☐ Excessive Ground Power
- ☒ Takeoff Events
  - ☐ Heading Variation on Takeoff
  - ☐ Low Takeoff Rotation RPM
  - ☐ Low Takeoff Rotation IAS
  - ☐ Excessive Pitch at Takeoff Rotation
  - ☐ Excessive Takeoff Bank
  - ☐ Excessive Takeoff Tailwind
- ☒ Climb Events
  - ☐ Low Climb IAS
  - ☐ Excessive Climb Bank
  - ☐ Descent During Climb Phase
  - ☐ Excessive Climb Crosswind
- ☒ Flight Events
  - ☒ Approach Events
    - ☐ Max Bank During Approach
    - ☐ Min Vertical Speed During Approach
    - ☐ Max IAS During Approach
    - ☐ Min IAS During Approach
    - ☐ Max Tailwind During Approach
    - ☐ Max Crosswind During Approach
  - ☒ Landing Events
    - ☐ Min Touchdown Pitch
    - ☐ Max Touchdown Pitch
    - ☐ Max Touchdown IAS

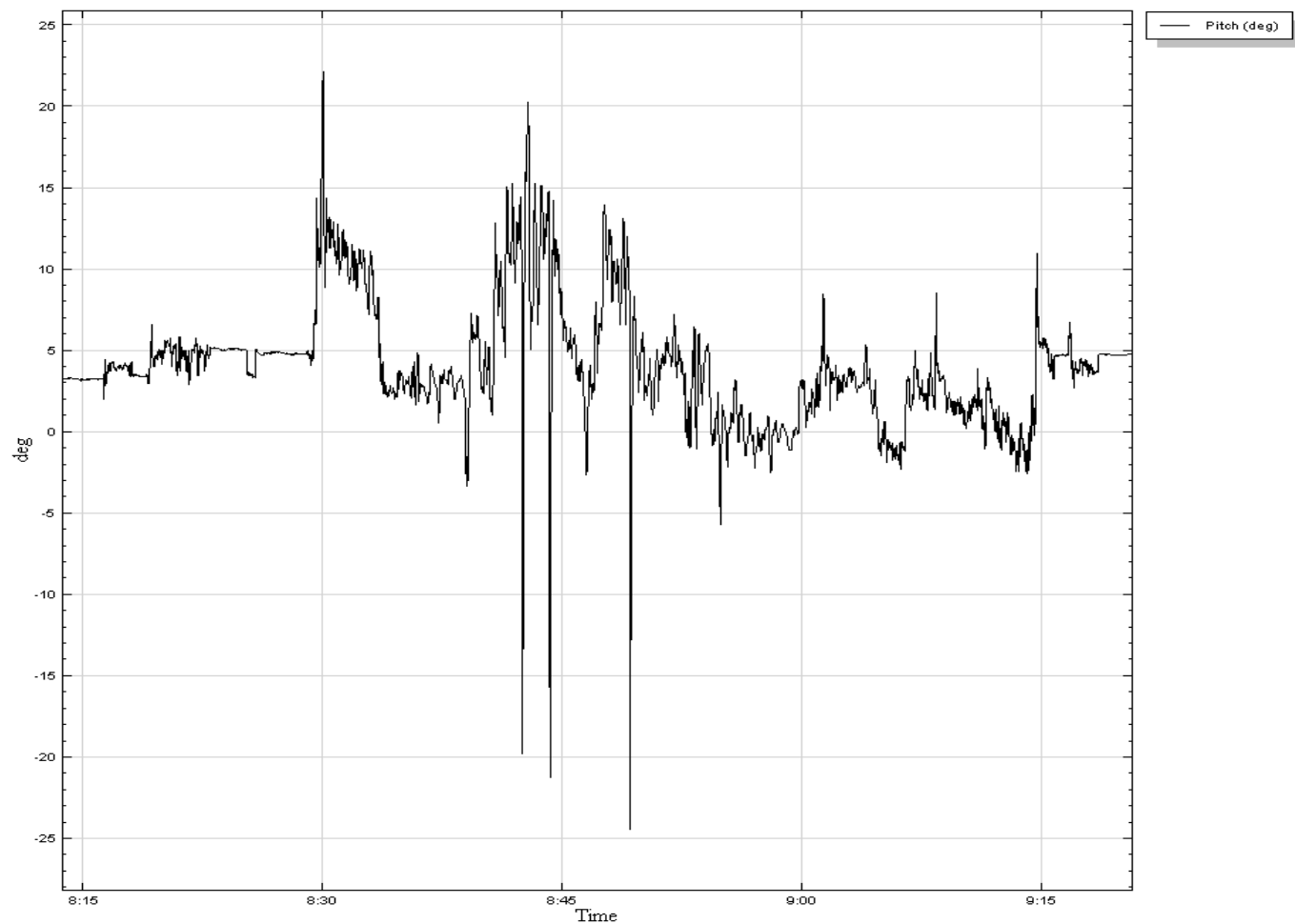
## Run Analysis

Start Analysis

Abort Analysis

- ☒ Archive Files After Analysis ☒ Use Google Earth
- ☒ Save Events in Database

Pitch vs. Local Time



## ▼ Search

Fly To Find Businesses Directions

Fly to e.g., Reservoir Rd., Clayville, NY

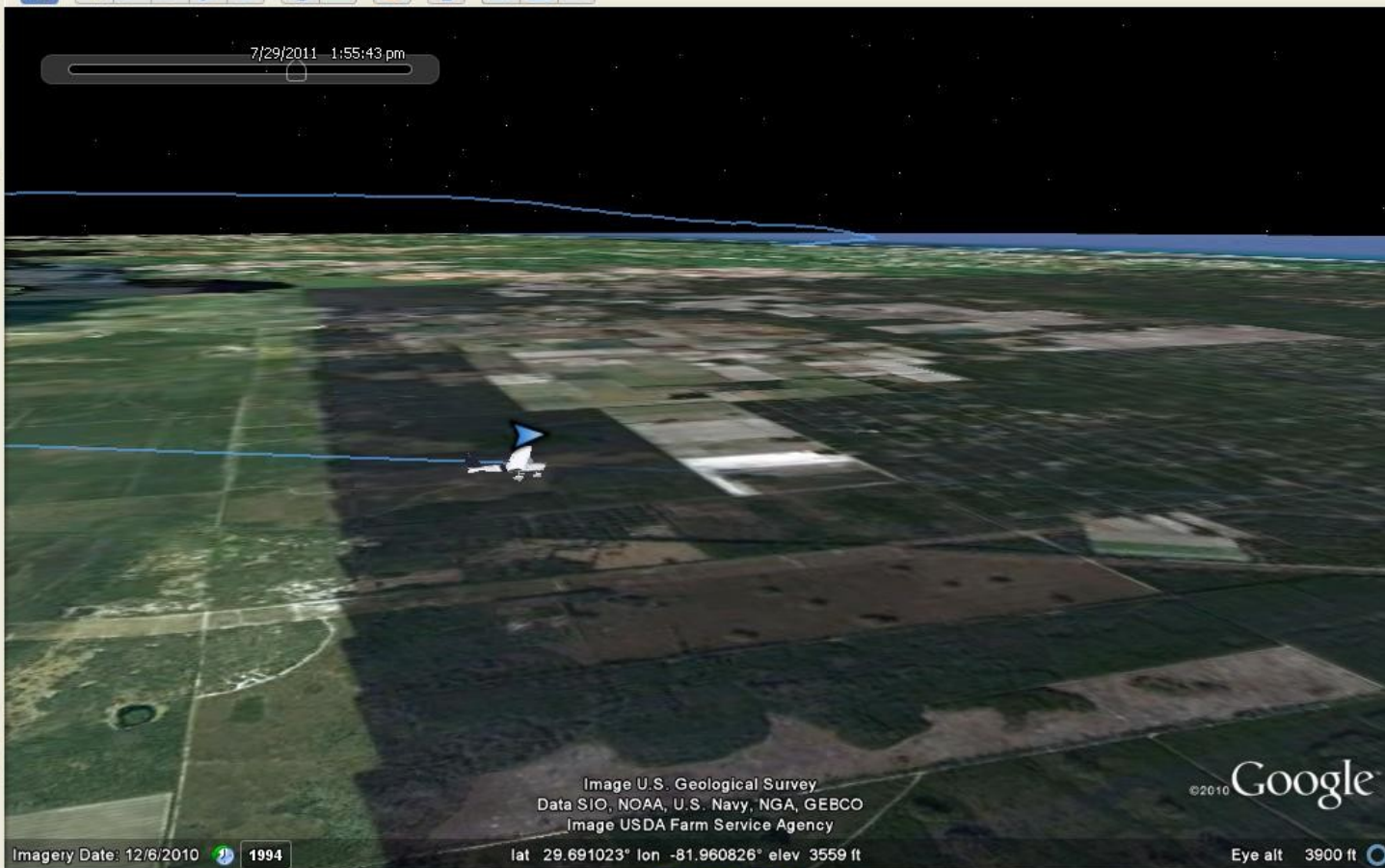
## ▼ Places

- ✓ My Places
- Temporary Places

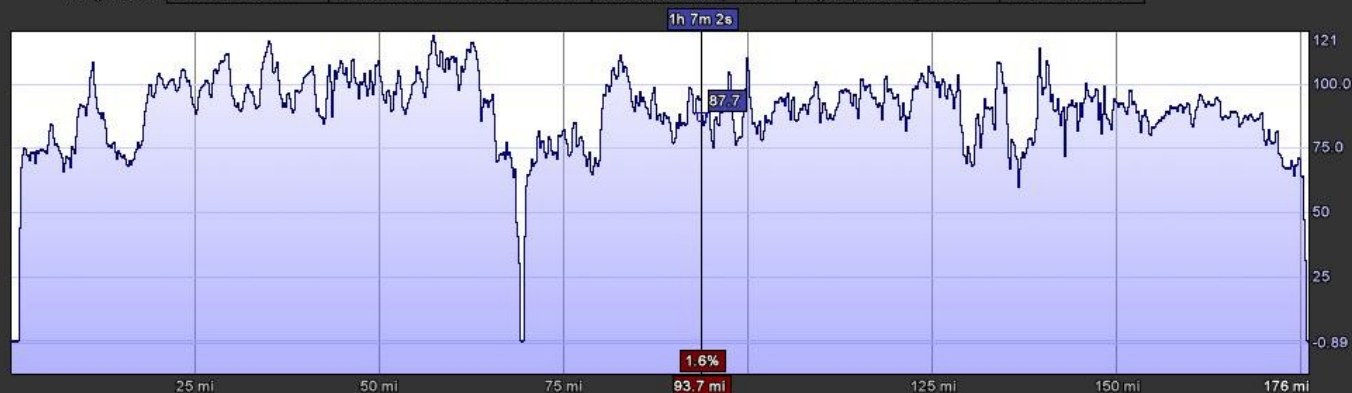
## ▼ Layers

Earth Gallery &gt;&gt;

- Primary Database
- Borders and Labels
- Places
- Photos
- Roads
- 3D Buildings
- Ocean
- Weather
- Gallery
- Global Awareness
- More



Graph: Min, Avg, Max Elevation: -41, 2828, 4871 ft Speed: 1.9, 85.6, 146.2 mph IAS: 0, 88.6, 119 E1 RPM: 0, 2240, 2574  
Range Totals: Distance: 176 mi Elev Gain/Loss: 17536 ft, -17468 ft Max Slope: 12.5%, -15.0% Avg Slope: 3.0%, -2.8% Time: 2h 3m 30s







File Tools Help

Data Viewing Data Analysis Event Database

DataGrid View

Select Columns to Display:

- ☐ Local Date
- ☐ Local Time
- ☐ UTC Offset
- ☐ Active Waypoint
- ☐ Latitude
- ☐ Longitude
- ☐ Barometric Altitude
- ☐ Barometric Setting
- ☐ Altitude MSL
- ☐ QAT
- ☐ IAS
- ☐ Groundspeed

☐ Select All

Show Data Grid

Data Plotting

Select Independent Variable (X-Axis)

Local Time

Choose...

Select Dependent Variables (Y-Axis)

E1 CHT1  
E1 CHT2  
E1 CHT3  
E1 CHT4

Variable Options

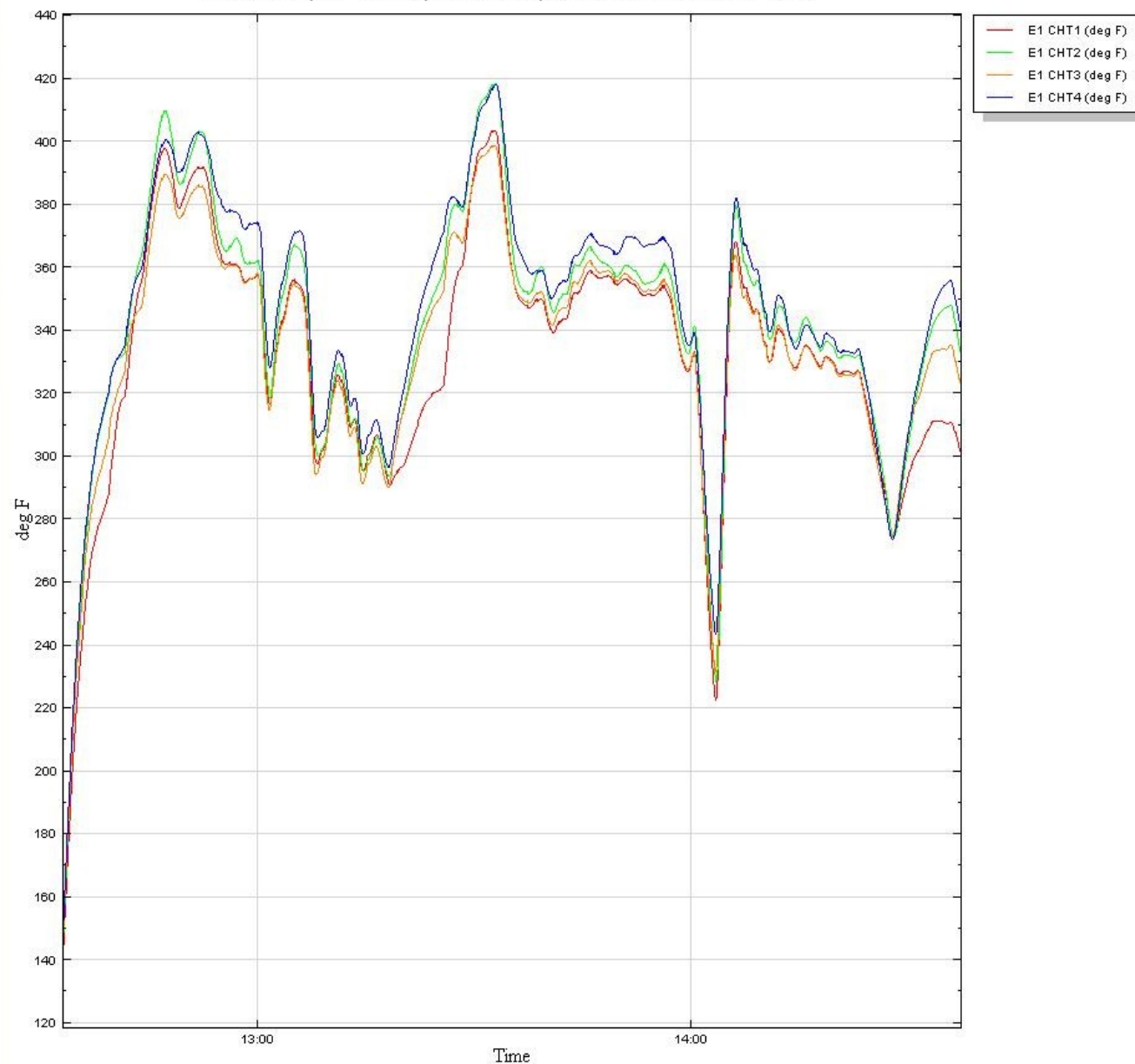
Add

Remove

Plot Options

Show Data Plot

E1 CHT1, E1 CHT2, E1 CHT3, E1 CHT4 vs. Local Time

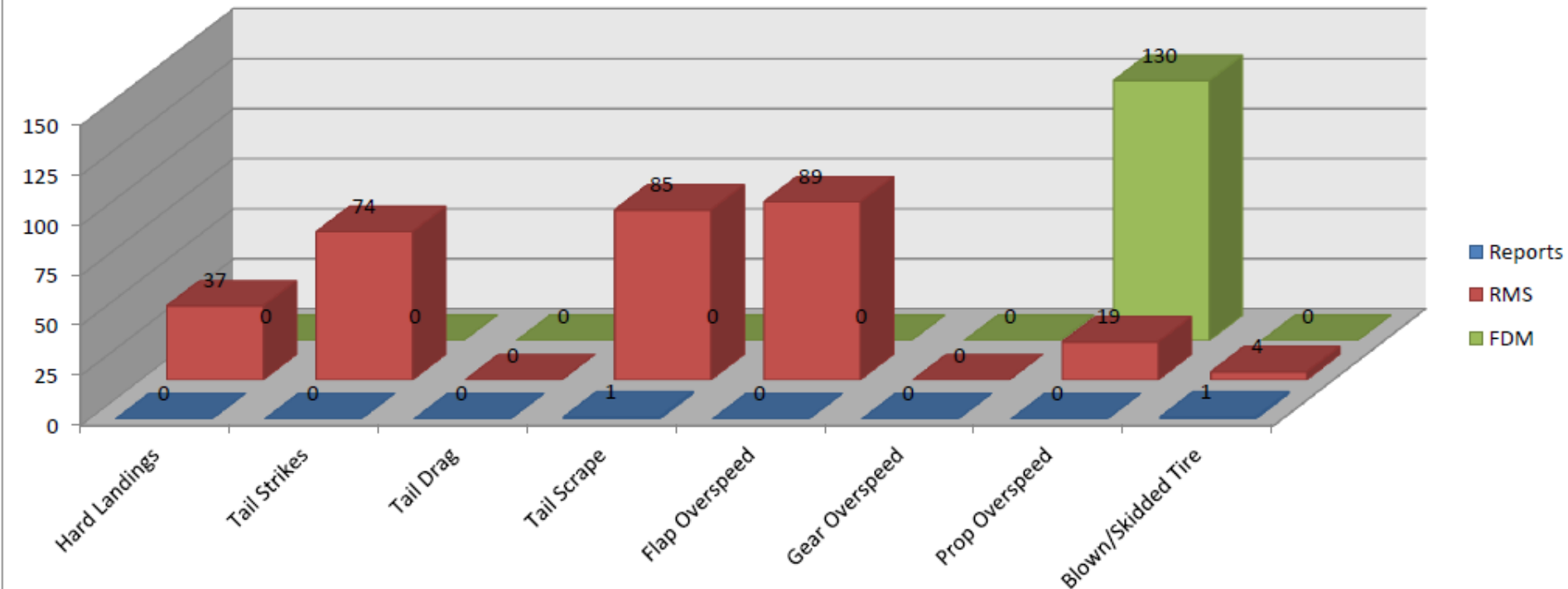


# Reports vs. FDM Data



## ***SAFETY REPORTS vs. RMS***


Summer 2011



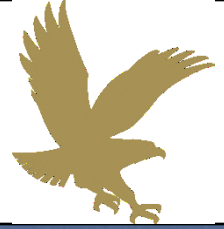




# Benefits of FDM

- ▶ A tool for monitoring safety, quality, and professionalism
  - ▶ Identify parameters that have been exceeded
  - ▶ Incident/accident investigation
  - ▶ Research/Procedure development
  - ▶ Research/ health monitoring
  - ▶ Maintenance issues
  - ▶ Added value to training/de-briefing
- 





**“Safety-Quality-Professionalism”**  
**Professor Ken Byrnes**